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(54) **A method of time measurement in a communications system, a communications system and a receiving apparatus for use in the system.**

(57) In certain signal transmission systems such as selective call systems it is desired to stamp the date and time of the receipt of a call addressed to a receiver. For battery powered equipments such as radiopagers it is not practical to provide a clock because it will require resetting after each battery change. Fairly accurate times can be obtained by the system base station transmitting date and time message signals at regular intervals. However due to signal formatting delays and signal propagation delays, both of which are variable, the time indicated in a received time message signal is incorrect relative to real time. A radiopager includes a timing stage which is able to measure real time relative to a time reference. In order to obtain the best time reference, a comparison is made between the real time difference ($Tr_n - Tr_{ref}$) between the times of receipt Tr_{ref}, Tr_n of a current time reference signal and a more recently received time message signal Ts_{ref}, Ts_n, and the time difference ($Ts_n - Ts_{ref}$) between the times Ts_{ref}, Ts_n indicated in the corresponding time message signals, and depending on the result either the time reference signal Ts_{ref} is confirmed as the current time reference signal or the more recently received time message signal is substituted as a new current time reference signal causing the real time clock to be reset so as to relate the real time to the new current time reference signal.

The present invention relates to a method of time measurement in a communications system, a communications system and a receiving apparatus for use in the system. The present invention has particular application to cordless telephone and selective call, such as digital radiopaging, systems.

For convenience of description the present invention will be described in the context of a digital radiopaging system.

US Patent Specification 4 845 491 discloses a digital pager which is operable in accordance with the CCIR Radiopaging Code No. 1 standard otherwise known as POCSAG. In order for a user to be able to review chronologically messages stored in a memory, each message is stamped with the date and time of receipt. Date and time message signals are periodically transmitted by a paging network controller (PNC). With respect to the time message signals, delays of up to 15 minutes may occur before they are transmitted. In order to correct any errors in the pager clock, the next following time message signal as transmitted includes an indication of the error in the previously transmitted time message signal, that is delay in its transmission. Thus the pager clock can be updated on the basis of knowing the previous time message signal (t_{n-1}), the correction C_n representative of the difference between the time indicated in the previous time message signal and the time of its actual reception, and knowing the time difference, as measured by a real time clock, between the times of receipt of the previous (T_{n-1}) and of the current (T_n) time message signals. The cited specification gives the following formula for determining the updated time $T_{n(new)}$, viz

$$T_{n(new)} = t_{(n-1)} + C_n + (T_n - T_{(n-1)}).$$

Whilst this known technique for measuring real time is accurate, it nevertheless requires two message transmissions from the paging network controller and a remote receiver for comparing each time message against a reference time standard.

An object of the present invention is to simplify real time measurement by a receiver.

According to a first aspect of the present invention there is provided a receiving apparatus for use in a communications system in which a succession of time messages are transmitted by a central station, characterised in that the receiving apparatus comprises means for receiving and decoding successive time message signals, means for storing the time indicated in the time message signals, timing means for determining the real time of receipt of each time message signal, and means for determining by using the time message signals and the real times of their receipt, which of the time message signals is to be treated as a current time reference signal to which the real time signals of the timing means are to be related.

According to a second aspect of the present invention there is provided a communications system comprising a central station having means for transmitting a succession of time message signals, each time message signal containing an indication of time, receiving means for receiving the time message signals, the receiving means having a real time clock and means for determining by using the time message signals and the real times of their receipt which of the time message signals is to be treated as a current time reference signal to which the time of the real time clock is related.

According to a third aspect of the present invention there is provided a method of time measurement in a communications system, comprising transmitting a succession of time message signals from a central station, each time message signal containing an indication of time, receiving the time message signals in a receiving apparatus having a real time clock, determining by using the time message signals and the real times of their receipt which of the time message signals is to be treated as a current time reference signal to which the time of the real time clock is related.

Compared to the system disclosed in US Patent Specification 4 845 491 the present invention simplifies the measurement of time by the determination of a time reference being made solely in the receiving apparatus, there being no necessity for the central station having to transmit correction signals.

The means for determining which of the time message signals is to comprise the current time reference signal, may comprise means for determining the time difference between the indicated times in the current time reference signal and a more recently received time message signal, means for determining the time difference between the real times of receipt of the current time reference signal and the more recently received time message signal and comparison means for comparing the indicated time difference with the real time difference and depending on the result either the time reference signal is confirmed as the current time reference signal or the more recently received time message signal is substituted as a new current time reference signal causing the real time clock to be reset so as to relate the real time to the new current time reference signal. By determining which time message signal is the more accurate then by using it as a reference signal the indicated time is closer to the true time.

If desired, whenever the real time difference exceeds a predetermined value, the most recently received time message signal is treated as a new

time reference signal. Such a step enables a receiving apparatus which is receiving time message signals to automatically update the indicated time when changing time zones, for example on arrival at an airport.

The time message signal as transmitted may include a correction relating to the minimum delay incurred between the generation of a time indication signal at the central station and the transmission of the corresponding time message signal. By including such a correction in the time message signal as transmitted, the variable time delay due to signal propagation between the central station and the receiving apparatus is relatively small, thereby ensuring that the current time reference signal is as accurate as possible.

In an embodiment of the present invention the central station transmits digital paging signals in accordance with a time division protocol comprising a succession of batches, each batch comprising a plurality of frames. The time message signals are transmitted periodically and a time message signal in a batch is preceded by an indicator signal including function bits denoting that codewords in the same and at least the next following frame(s) comprise the time message signal. The use of an indicator signal contributes to the battery power conservation in the receiving apparatus because it can switch off its receiver on determining that the correct function bits are not present.

The symbols in the time message signals may be encoded as hexadecimal characters which requires fewer bits than alternative codes such as ASCII 7 bit coding. An advantage of using a numeric only code rather than an alphanumeric code is that fewer codewords are required to send the time message signals which does not reduce significantly the overall system capacity.

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein

Figure 1 is a block schematic diagram of a selective call system,

Figure 2 is a diagram of the POCSAG signal format,

Figure 3 is a diagram illustrating the sending of date and time message signals in every 1 in N batches, where N is an integer greater than 1, for example 8,

Figure 4 is a block schematic diagram of a selective call receiver,

Figure 5 is a graph illustrating the determination of the best time message signal to use as a reference, and

Figure 6 is a flow chart illustrating measuring time in accordance with the present invention.

In the drawings the same reference numerals have been used to illustrate corresponding features.

The selective call system shown in Figure 1 comprises a paging network controller (PNC) 10 which is equipped with a transmitter 12 and a controller 14 which includes means for formatting signals to be transmitted, the signals may comprise pager identity codes (RICs) and/or message data such as date and time. A clock or other time reference source 15 is connected to or forms a part of the PNC 10.

A plurality of paging receivers (or pagers) P1 to P4 are provided. The pagers are able to roam in and out of the coverage area of the transmitter 12. Each pager P1 to P4 includes a radio receiver 16 tuned to the frequency of the transmitter 12 and a controller 18 which controls the energisation of the radio receiver 16, the date and time stamping of received alert and/or message signals and the energisation of an alerting device, for example an acoustic, visual and/or tactile transducer, in the event of the controller identifying the pager's RIC in a transmitted message.

The signal format is CCIR Radiopaging Code No. 1 or POGSAG and for the sake of completeness it will be described briefly with reference to Figure 2. However for fuller information reference may be made to "The book of the CCIR Radiopaging Code No. 1" available from: Secretary RCSG, British Telecom, Radiopaging, 23 Howland Street, London W1P 6HQ. The transmissions from the PNC 10 comprises a series of bursts, each burst comprising a preamble 20 of 576 bits which serves to enable the pagers P1 to P4 achieve bit synchronisation, followed by concatenated batches of codewords formed by Radio Identity Codes (RICS) and data messages. Each batch 22,24 is arranged identically and comprises seventeen 32-bit codewords. The first codeword is a synchronisation codeword 26 which is used by a pager to achieve/maintain word synchronisation. The remaining sixteen codewords are paired and each of the eight pairs is termed a frame, F1 to F8. Each pager is assigned to a particular frame which means that, if necessary its RIC, or more precisely any one of its RICs, will be transmitted in that frame, say frame F4, and no other. Thus as part of the inherent battery power conservation feature of POCSAG, the pager must energise its radio receiver 16 firstly to be able to receive the synchronisation codeword 26 and secondly for the duration of its frame, in this example F4, but for the duration of the other frames, that is F1 to F3 and F5 to F8, the receiving section 16 can be deenergised.

Data messages comprise an address codeword plus one or more concatenated message codewords.

With respect to the transmission of date and time messages, these may be sent at regular intervals, for example once in every N batches, where N has a value of two or more, for example N = 8, or once in every burst or less frequently, in order that battery power conservation may be practised in a predetermined manner. For the purposes of illustration the following description will assume that N = 8 batches.

Referring to Figure 3, every N, where N = 8, batches form a superbatch SB and once in every superbatch date and time information in the form year, month, day, hour, minute, second and thousands of a second, such as 92/02/20 12 hours, 10 minutes, 21 seconds and 357/1000th of a second, is transmitted as 4 bit hexadecimal characters by the PNC 10 in frames F1 and F2 of batch 0. More particularly the first codeword in the frame F1 includes function bits indicative of either that the following 3 codewords contain date and time information or not. A paging receiver or pager wishing to receive such a message signal is programmed to energise its radio receiver 16 in order to not only receive the synchronisation word (or sync. word) but also to remain energised for frame F1 of batch 0 in order to be able to check that the first codeword contains function bits indicative of the fact that date and time information is to follow. In response to detecting this codeword, the pager remains energised for the remainder of the frame F1 and for the frame F2. Thereafter the pager is energised in the normal way to receive the synchronisation codeword 26 in each batch and to be able to receive its RIC in its assigned frame.

Referring to Figure 4, the pager P comprises a housing, shown in broken lines, which contains a radio receiver 16 and a controller 18 with associated circuits and devices. The radio receiver 16 can be of any suitable design, for example one based on Philips low power digital paging receiver IC type UAA 2033T or type UAA 2050T and the controller 18 may be based on the Philips DCA 5000T decoder. More particularly the controller 18 comprises a decoder 28 connected between an output of the receiver 16 and an input to the controller 18. The decoder 28 accepts any signal received during the period(s) when the receiver is energised, error checks and corrects any errors possible within the capacity of the POCSAG code and presents the signals, codeword by codeword, to the controller 18 which as a first action checks whether the address codeword corresponds to one of the radiopager's RICs stored in the controller's non-volatile memory. If there is correspondence then in the case of an alert only paging signal, the controller 18 causes an audio, visual and/or tactile alerting device 30 to be energised. In the case of the received signal comprising concatenated message codewords then the controller 18 stores these together a date and time stamp in a RAM 32. In response to a command produced by the subscriber actuating a button on a keypad 34, the controller 18 causes the contents of the RAM 32 to be read out and supplied to the driver 36 of an LCD panel 38.

In the event of there not being correspondence between the received address codeword(s) and the radiopager's RIC, the controller 18 takes no action.

A timing stage 40 is connected to the controller 18 and provides timing signals to the controller 18 so that it can carry out various operations including battery power conservation which is inherent in the POCSAG code.

The timing stage 40 also includes a real time clock 42. On receipt of successive date and time messages, the controller stores the year, month and date in a RAM 44 together with time, after the time indicated in the time message signal has been adjusted to take into account the delays incurred in encoding and formatting the time message signal and propagation delays in transmitting signals to pagers P1 to P4 which may be roaming throughout the coverage area of the base station transmitter 12 (Figure 1).

Referring to Figure 1, a time signal Tc is generated by the clock 15 and is supplied to the controller 14 which adapts the signal to a message format and stores it temporarily in readiness for transmission by the transmitter 12 at the required moment, for example in frames F1 and F2 of batch 0 of the superbatch SB. The date and time signal is received by those pagers adapted to receive these signals. However the actual time of receipt will depend on the distance from the antenna of the PNC 10. Consequently there will be a variable delay between the origination of the time signal Tc and its actual time of receipt by a roaming pager.

The delay comprises two main elements, firstly the time delay within the PNC 10 and secondly the propagation time to the respective pager. In accordance with the present invention a pager treats one of the received time message signals as a reference and its internal clock counts the time from that reference. However as the time message signal which is used as a reference may not be the optimum signal, the pager compares each newly received time message signal with the current reference and decides if the newly received time message signal is more accurate.

The processing of the time signal Tc in the PNC 10 is assumed to involve a minimum time delay Td_m. Accordingly the accuracy of the time indicated in a time message signal Ts is improved if Td_m is added to Tc, thus

$$Ts = Tc + Td_m \quad (1)$$

The propagation time to a pager plus the excess time over Td_m in PNC 10 introduces a variable delay Td_v. In consequence the real time at the pager, Tr, of the receipt of the time message signal is:

$$Tr = Tc + Td_m + Td_v \quad (2)$$

Substituting equation (1) into equation (2)

$$Tr = Ts + Td_v \quad (3)$$

If two signals Ts_1 and Ts_2 are in a sequence of time message signals then from equation (3)

$$Tr_1 = Ts_1 + Td_{V1} \quad (4)$$

and $$Tr_2 = Ts_2 + Td_{V2} \quad (5)$$

Subtracting equation (4) from equation (5), we get

$$(Tr_2 - Tr_1) = (Ts_2 - Ts_1) + (Td_{V2} - Td_{V1}) \quad (6)$$

Examining equation (6), Ts_1 and Ts_2 are known, Tr_1 and Tr_2 are measured at the pager and Td_{V1} and Td_{V2} are unknown but can be calculated from equation (3), (4) or (5). However the smaller the value of Td_v, the closer Tr is to Ts and therefore the more accurate the value of Tr.

Rewriting equation (6) we get

$$(Tr_2 - Tr_1) - (Ts_2 - Ts_1) = (Td_{V2} - Td_{V1}) \quad (7)$$

If $(Td_{V2} - Td_{V1})$ is positive then Td_{V1} is smaller than Td_{V2} and therefore Tr_1 is closer to its time message signal Ts_1 than Tr_2 is to Ts_2. Conversely if it is negative then Td_{V2} is smaller than Td_{V1} and the opposite applies.

Accordingly at switch-on of the pager, two successive times are noted and the computation shown in equation (7) is carried out in the controller 18 (Figure 4) and the right hand side of the equation is examined as to the sign of the difference and if it is positive then Ts_1 is treated as the current reference signal, Ts_{ref}, and the real time clock 42 (Figure 4) counts from Tr_1. The opposite situation applies if the sign is negative and the real time clock 42 counts from Tr_2.

Thereafter on receipt of a subsequent time message signal Ts_n, equation (7) is solved for

$$(Tr_n - Tr_{ref}) - (Ts_n - Ts_{ref}) = (Td_{vn} - Td_{vref}) \quad (8)$$

For as long as the sign of the right hand side of the equation remains positive, the same reference is maintained. However if the sign is negative, then the newly received time message signal Ts_n is treated as the reference and the real time clock 42 is adjusted to treat Tr_n as zero and to start its count from there. This is illustrated in Figure 5 in which time message signals Ts_5 and Ts_7 are assumed to become new reference signals.

In the event of the right hand side of equation (7) being zero, then the accuracy of Tr_n and Tr_{ref} is the same and the pager can either change its reference signal or keep its existing reference signal.

If the size of the difference in equation (7) is measured as well as determining the sign of the difference then the clock in the pager can be updated automatically for a change in time zones, which facility can be useful for automatically altering the time indicated on a watch or another device having a pager, such as a pocket sized personal computer having means for displaying time.

Thus if a traveller disembarking at say an airport has a pager which is able to receive paging signals containing date and time message signals, then if when the newly received timing message signal is compared to the current reference signal, Ts_{ref}, the difference exceeds the time equivalent of say 15 minutes, the controller 18 assumes that Ts_{ref} is grossly incorrect and assumes that the newly received signal is more correct and treats it as a new reference signal and simultaneously stores Ts_n in the RAM 44 (Figure 4) and updates the indicated time to that contained in the time message signal. Thereafter the pager behaves as described previously.

The operation of selecting or verifying that Ts_{ref} is the best is described by equation (8). One method for implementing equation (8) is shown in Figure 6. The difference $(Tr_n - Tr_{ref})$ is stored in a counter or store A. The time message signal Ts_{ref} is stored in a store B and the latest received time message signal Ts_n is stored in a store C and finally Tr_n, which is the current time displayed, is stored in store D which has an input coupled to the clock 42 and an output coupled to a display device 50.

From the items stored and the operations carried out in blocks 52,54, if the output of decision stage 56 is "Yes" (Y), that is $A - (C - B) \geq 0$, then the operations in blocks 58 and 60 are inhibited by the respective N inputs. As a result the time reference Ts_{ref} is retained and stores A,C,D are incremented normally.

Alternatively if the output of the decision stage 56 is "No" (N), then as a result of a new Ts_{ref} being selected store A is reset to zero and blocks 58,60 are enabled by the signal on the Y inputs so that the current value of Ts_n is loaded into store B to become the new Ts_{ref} and into store D to indicate the current time on the display device 50.

In a variant of the method in accordance with the present invention, the clock time Tc is transmit-

ted as the time message signal without being altered by the addition of Td_m, as a result Td_v is greater due to having to take Td_m into account. Hence the value of Ts_{ref} may be less accurate than the example described with reference to Figure 1. However for certain applications the reduced accuracy in Ts_{ref} can be tolerated.

If desired the correction value Td_m may be added to the indicated time on the pager when it has not been taken into account at the PNC 10.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of receiving systems for measuring time and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

Claims

1. A receiving apparatus for use in a communications system in which a succession of time messages are transmitted by a central station, characterised in that the receiving apparatus comprises means for receiving and decoding successive time message signals, means for storing the time indicated in the time message signals, timing means for determining the real time of receipt of each time message signal, and means for determining by using the time message signals and the real times of their receipt, which of the time message signals is to be treated as a current time reference signal to which the real time signals of the timing means are to be related.

2. An apparatus as claimed in claim 1, characterised in that the means for determining which of the time message signals is to comprise the current time reference signal, comprises means for determining the time difference between the indicated times in the current time reference signal and a more recently received time message signal, means for determining the time difference between the real times of receipt of the current time reference signal and the more recently received time message signal and comparison means for comparing the indicated time difference with the real time difference and depending on the result either the time reference signal is confirmed as the current time reference signal or the more recently received time message signal is substituted as a new current time reference signal causing the real time clock to be reset so as to relate the real time to the new current time reference signal.

3. A communications system comprising a central station having means for transmitting a succession of time message signals, each time message signal containing an indication of time, receiving means for receiving the time message signals, the receiving means having a real time clock and means for determining by using the time message signals and the real times of their receipt which of the time message signals is to be treated as a current time reference signal to which the time of the real time clock is related.

4. A system as claimed in claim 3, characterised by means for determining whether the time message signal treated as the current time reference signal is more accurate than a more recently received time message signal, said means comprising means for determining the difference between the indicated times in the current time reference signal and the more recently received time message signal, means for determining the difference in the real times of receipt of the reference signal and the more recently received time message signal, and means for comparing the indicated time difference with the real time difference and depending on the result either the time reference signal is confirmed as the current time reference signal or the more recently received time message signal is substituted as a new current time reference signal causing the real time clock to be reset so as to relate the real time to the new current time reference signal.

5. A system as claimed in claim 4, characterised by means responsive to the real time difference exceeding a predetermined value for treating the most recently received time message signal as a new time reference signal.

6. A system as claimed in claim 3, 4, or 5, characterised in that the central station includes means for generating a time indication signal and means for updating the time indication signal by a correction relating to the minimum delay incurred in the central station.

7. A system as claimed in any one of claims 3 to 6, characterised in that the central station transmits digital paging signals in accordance with a time division protocol comprising a succession of batches, each batch comprising a plurality of frames, said time message signals being transmitted periodically, and in that the central station has means for inserting into a batch an indicator signal including function bits denoting that codewords in the same and at least the next following frame(s) comprise the time message signal.

8. A method of time measurement in a communications system, comprising transmitting a succession of time message signals from a central station, each time message signal containing an indication of time, receiving the time message signals in a receiving apparatus having a real time clock, determining by using the time message signals and the real times of their receipt which of the time message signals is to be treated as a current time reference signal to which the time of the real time clock is related.

9. A method as claimed in claim 8, characterised by determining whether the time message signal treated as the current time reference signal is more accurate than the more recently received time message signal by determining the difference between the indicated times in the current time reference signal and the more recently received time message signal, determining the difference in the real times of receipt of the reference signal and the more recently received time message signal, comparing the indicated time difference with the real time difference and depending on the result either the time reference signal is confirmed as the current time reference signal or the more recently received time message signal is substituted as a new current time reference signal causing the real time clock to be reset so as to relate the real time to the new current time reference signal.

10. A method as claimed in claim 8 or 9, characterised in that the central station transmits digital paging signals in accordance with a time division protocol comprising a succession of batches, each batch comprising a plurality of frames, in that time message signals are transmitted periodically and in that a time message signal in a batch is preceded by an indicator signal including function bits denoting that codewords in the same and at least the next following frame(s) comprise the time message signal.

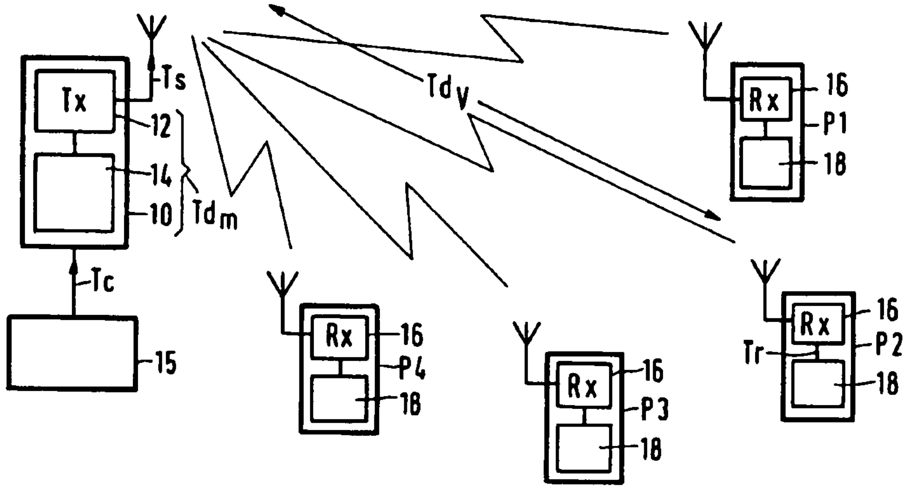

FIG.1

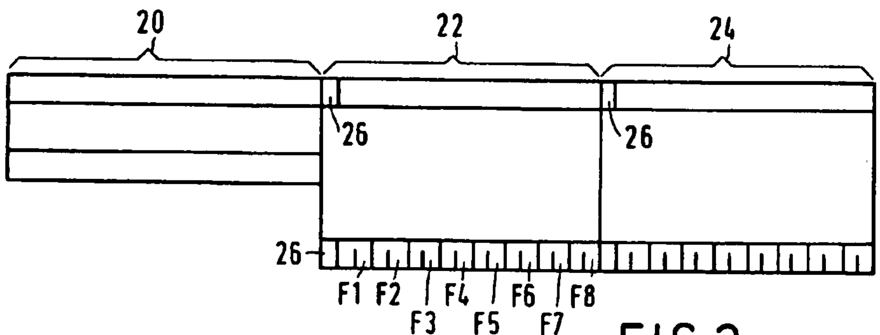

FIG.2

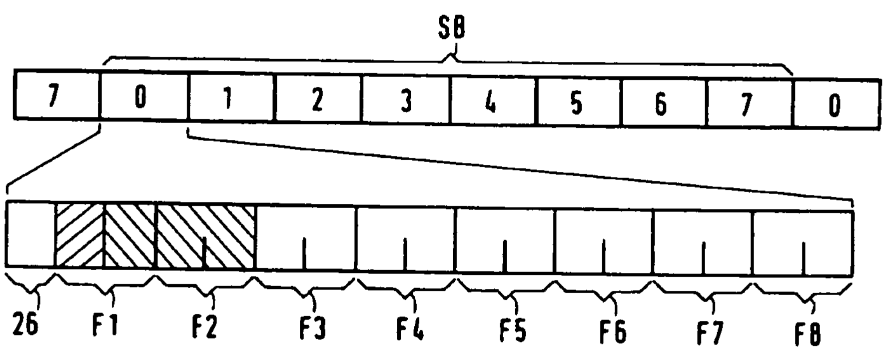

FIG.3

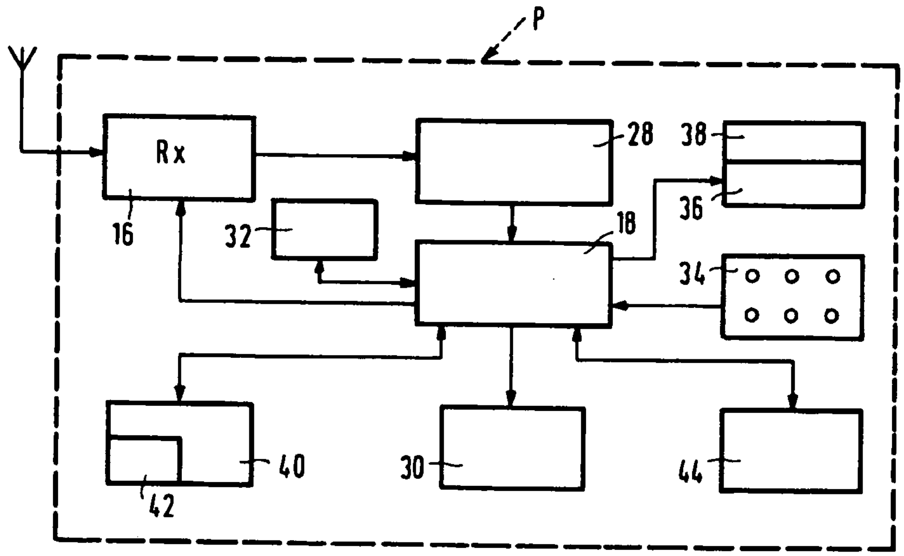
P
Rx
16
32
28
18
38
36
34
40
42
30
44

FIG.4

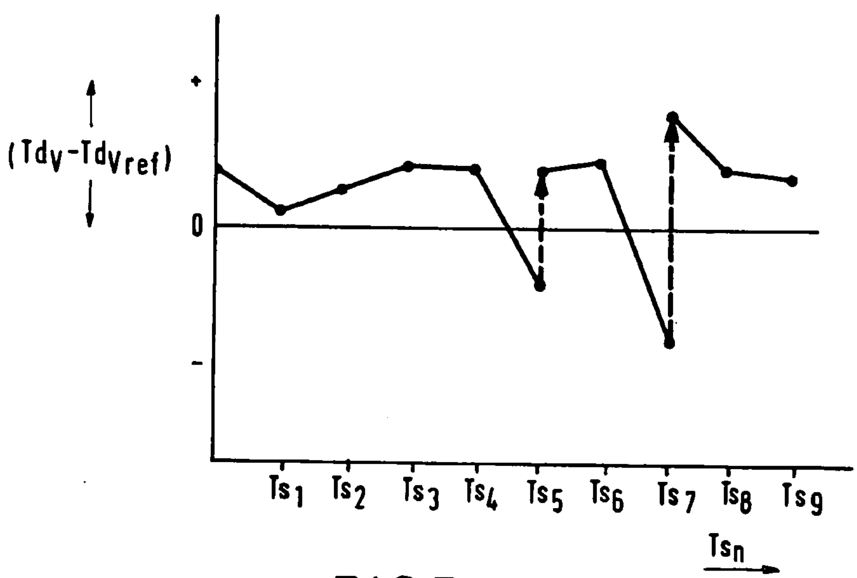
+
(Tdv-Tdvref)
0
-
Ts1
Ts2
Ts3
Ts4
Ts5
Ts6
Ts7
Ts8
Ts9
Tsn

FIG.5

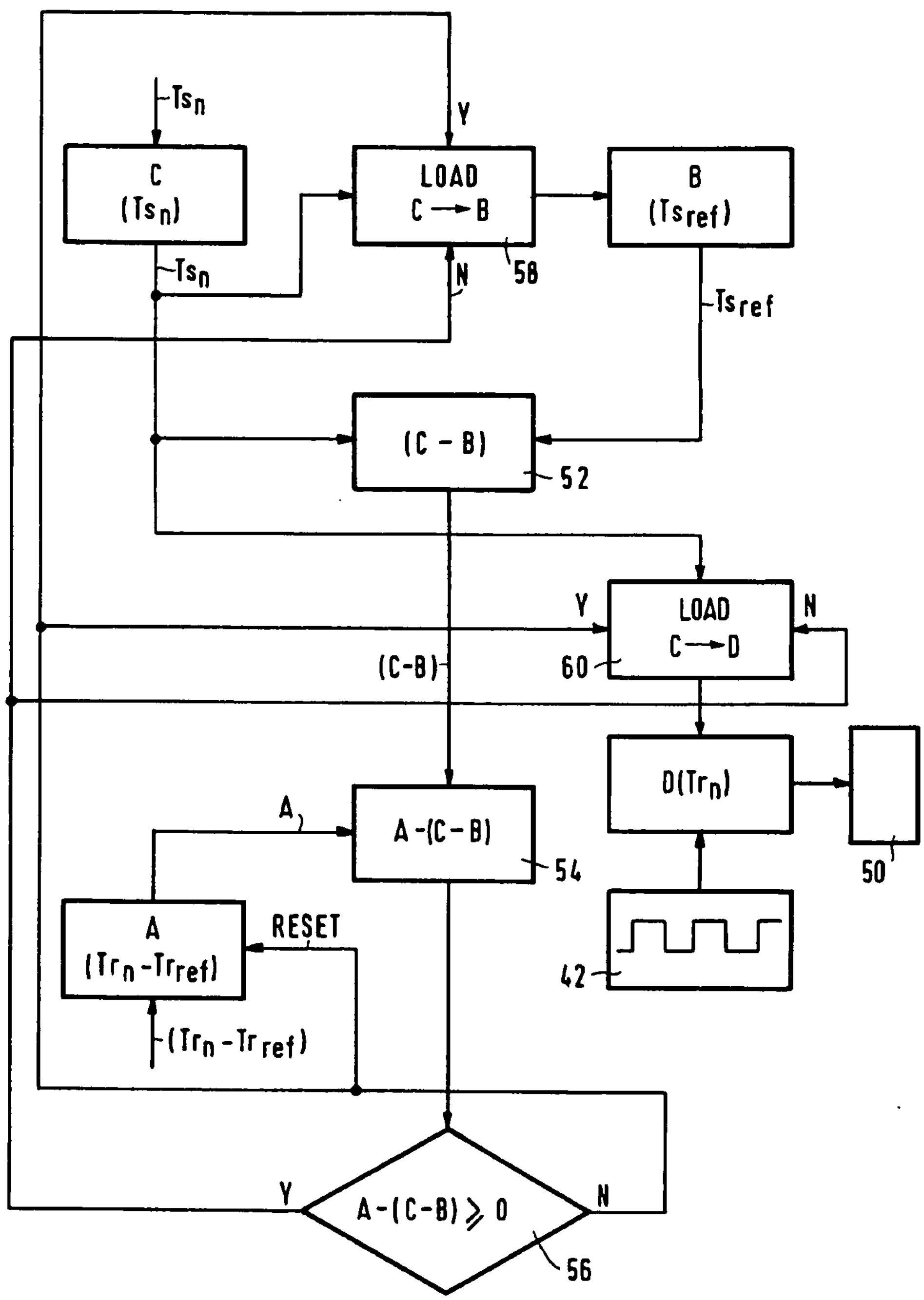
Tsn
Y
C
(Tsn)
LOAD
C → B
B
(Tsref)
Tsn
N
58
Tsref
(C – B)
52
Y
LOAD
C → D
N
(C-B)
60
D(Trn)
A
A -(C – B)
54
50
A
(Trn -Trref)
RESET
42
(Trn -Trref)
Y
A -(C-B) ≥ 0
N
56

FIG.6